**National Aeronautics and Space Administration**

**Office of Space Science**

# STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE

**OF THE**
**SPACE SCIENCE ADVISORY COMMITTEE**

**December 3-4, 2001**

**Cocoa Beach, FL**

# MEETING REPORT

**Paul Hertz**
**Executive Secretary**

**Bruce H. Margon**
**Chair**

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
December 3-4, 2001
Cocoa Beach, FL

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***Monday, December 3***

Welcome/Introduction
Dr. Bruce Margon, Chair of the Structure and Evolution of the Universe Subcommittee (SEUS), welcomed the Subcommittee members and attendees to the meeting and introduced the four new members: Lynn Cominsky, Sonoma State University; Kathryn Flanagan, Massachusetts Institute of Technology; Nicholas White, NASA/Goddard Space Flight Center (GSFC); and Harold Yorke, Jet Propulsion Laboratory (JPL). Dr. Margon noted that this would be his last SEUS meeting as Chair. He will be replaced by Dr. Edward (Rocky) Kolb. Dr. Sterl Phinney, Head of the SEU Roadmapping Team, introduced the Team members who were present at the meeting. Dr. Paul Hertz, Executive Secretary of the SEUS, made logistics announcements and briefly reviewed the meeting rules under the Federal Advisory Committee Act.

SEU Theme Update
Dr. Hertz provided an update on the SEU theme. All of the operating missions are "green." One of the issues concerning the Chandra mission is how to handle the grants. The impact of requiring grant administration by the Program (the government) rather than the Center (the contractor) is ten civil servants. Dr. Hertz reviewed the SEU missions in development. The Galaxy Evolution Explorer (GALEX), a Small Explorer (SMEX) currently scheduled to launch in May, is "red." It is over budget and behind schedule and has a technical problem with the X-band transmitter. There will be a programmatic review at Headquarters in early December. The Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) is "green," but the schedule is being reassessed based on a likely ICESAT launch slip. Gravity Probe (GP)-B is "red" due to problems encountered in testing and little margin in budget and schedule. Launch is still scheduled for October 2002. Integral is "yellow" due to some problems in shake test; it will stay yellow until it passes the test. Swift is also yellow. It has very little contingency left and may not be able to make its budget commitment. The prime mission was changed from three years to two years; however, it will still meet its science requirements. The Gamma ray Large Area Space Telescope (GLAST) is green at present. The NASA/DOE Implementing Agreement will be signed in December. Herschel is green. Planck is red because of problems in development. JPL has a "tiger team" working on this and will be reporting to NASA Headquarters in December. Constellation-X and LISA are in technology development (no details to report to the Subcommittee at this time). The Balloons Program (the infrastructure) has a long-term funding problem. A short-term (FY02) solution is being worked.

Dr. Hertz updated the Subcommittee on the Astronomy and Physics (A&P) solicitation for the next calendar year. The Next Generation Space Telescope (NGST) Announcement of Opportunity (AO) was released November 30. The instruments and science team are being solicited. The Chandra Cycle 4 will be released December 15 with the usual categories plus theory and modeling and archival. This solicitation will also include opportunity for joint proposals with Hubble Space Telescope (HST), NOAO, and X-ray Multiple Mirror (XMM). The Research Opportunity in Space Science (ROSS)-02 AO will be released in late January. The Senior Review for A&P missions will occur in the June timeframe. Proposals on the seven operating missions will be invited in February. Far Ultraviolet Spectroscopic Explorer (FUSE) Cycle 4 will be released in February. Rossi X-ray Timing Explorer (RXTE) Cycle 8 and Hubble Cycle 12 will be released in June. The next SMEX AO will be released no earlier than October 1 (probably sometime in late fall). The SMEX Phase A studies will be completed in a couple of weeks. Forty-three proposals were received in response to the recent MIDEX AO. Selection is scheduled for around early May.

In response to a question from Dr. Margon, Dr. Hertz did not identify any significant issues that he wanted the SEUS to address at this time.

Astronomy and Physics Division Update (Joint Session with the Origins Subcommittee)
Dr. Anne Kinney, A&P Division Director, discussed the new Space Science Enterprise organization, the working group structure in A&P, and the NASA Virtual Observatory (NVO). Currently, the Division is maintaining the theme division between Origins and SEU. The two themes are in different stages. Money

problems are dealt with according to level of importance and timing (launch). Dr. Kinney showed the program scientists and program executive assignments by mission, reflecting a high level of integration across the Division. The A&P Working Group (replacing the Astrophysics Working Group) will have a Chair and Co-Chair; one will serve on the Origins Subcommittee (OS) and one will serve on SEUS. There will also be a Science Archive Working Group (SAWG) because of the strong investment in archives within the Division. It will also have a Chair and Co-Chair, serving on OS and SEUS. Ad hoc working groups and workshops will be organized when required. Dr. Kinney reviewed the charters of the two new working groups.

NASA endorses the NVO concept and recognizes the high priority given to NVO in the Decadal Survey. However, it is unlikely to get a new start initiative with SMEX-level funding. It is too small to be an agency initiative, so the initiative must be built out of the ongoing program. The core of NVO already exists within the astrophysics data archive program, the data and computing technology program, and the data analysis research program. The three principal components of NVO are the data content, the data mining and exploration tools, and the grants program using NVO for research. The astrophysics data archive centers provide the core data content; the Applied Information Systems Research Program (AISRP) provides the core tool development resources. The Division intends to create a project office to implement NVO, highly leveraged from existing data centers. The funding source and schedule, the management approach and minimum success criteria, and the lead center for the project are yet to be determined. [Dr. Margon recused himself during the discussions on NVO.]

The major issues are the HST Servicing mission (the next launch), the Space Infrared Telescope Facility (SIRTF), and GP-B. SIRTF and GP-B are the major problems. Currently, their requests for additional funding are being evaluated. Dr. Kinney could not talk about the FY 03 budget, but indicated that she is optimistic. There will be more emphasis Agency-wide on managing to budget. The FY02 budget language indicated that NGST needs to be funded at the full level. NVO is not yet well-defined, and the archives working group will help define and develop this program. As a result of the Blue Ribbon Panel on NASA and NSF, OMB has requested that a joint NASA/NSF committee be formed. Dr. Kinney indicated that she could discuss the Space Operations Management Office (SOMO) funding issue in February.

Research and Analysis (R&A) Plans (Joint Session with SEUS)

Dr. Hashima Hasan discussed the strategic planning for the A&P research programs, the proposed restructuring of A&P research programs in FY03, and the A&P research programs in the ROSS-02 AO. A primary activity of the Astrophysics Working Group (AWG) has been collecting preliminary data for the roadmapping committee. Some workshops have been set up to obtain input from the community. In 2003, the Division is proposing that the research programs be grouped into two clusters: the A&P Supporting Research and Technology Program (including suborbital, detectors, supporting technology, laboratory astrophysics, ground-based, and fundamental physics); and A&P Research & Analysis (including Long Term Space Astrophysics, the Astrophysics Data Program (ADP), the Astrophysics Theory Program, and Origins of Solar Systems). Astrobiology is a question mark; the science addressing Astronomical Search for Origins (ASO) needs to be coordinated with the Exploration of the Solar System (ESS) Division. Dr. Hasan invited Subcommittee input on the proposed restructuring. It was noted that the Long Term Space Astrophysics (LTSA) Program is succeeding, but not in the way that it was originally envisioned (for junior researchers). The Subcommittee felt that the program has been very valuable to senior researchers. In response to a question, Dr. Kinney indicated that it is not clear at this point how the next R&A Senior Review will be organized. Subcommittee input would be welcome. In the ROSS-02 AO, A&P Programs will be solicited in three clusters: Astrophysics Theory and Data Analysis; Space Astrophysics R&A; and High Energy Astrophysics. There will be an overall budget augmentation of 3%. A new feature in the ADP program will be the solicitation of Type C proposals for science investigations requiring the development of information technology tools. Proposals must require the development of a new tool that can be applied more generally than the proposed science investigation. Proposals that make use of data archives from one or more NASA astrophysics data centers are encouraged. New theory initiatives will be solicited under HST Cycle 11 and Chandra Cycle 4.

Roadmap Team Report

Dr. Phinney provided an update on the SEU Roadmap activity. The Roadmap Team charter is on the SEU Web site. The one important issue is that the new funding line is something less than $200 million per year. Choices have to be made in each of the five-year cycles—one billion-dollar mission or two $500 million missions. Near term top priorities were Constellation-X, Laser Interferometer Space Antenna (LISA), and the Advanced Cosmic-ray Composition Experiment on the Space Station (ACCESS). ACCESS is off the table as a Roadmap mission because it is now allowed to be a MIDEX under the new rules. There is a lot of community input from all of the decadal surveys and the current NRC Committee on Physics of the Universe. White papers have been solicited, including those beyond the near-term missions. These are due January 31, 2002. Instructions are on the Web Site, including issues that the white papers should address. Dr. Phinney showed the Roadmap schedule. The Team will be meeting February 26-27, 2002, to develop the science goals and priorities. Future meetings will depend on the SScAC meeting schedule. By April, the Team will have made a choice on near and mid-term missions and what the science goals and priorities are. The Team will brief the SEUS on this. Technology development may impact what the near-term missions are. White papers should address technology needs. Dr. Allen is providing guidance on how all of the roadmap documents are to be structured across OSS. Dr. Margon asked for discussion on the calendar. He noted that the SEUS will be able to review the products in April and again in August. SEUS will have an opportunity for substantive input before May. Origins is in the process of adjusting and fine tuning; they will not be adding missions. On the other hand, this SEU roadmap will be very different from the last one. Dr. Hertz noted that there will be a lot of integration between Origins and SEU. However, the scientific justification must support the science objectives in each Roadmap.

Dr. Phinney reviewed a preliminary draft of the vision, the goals, and the research areas. In response to a question, he noted that all of this material is on the SEU Roadmap Website. Dr. Phinney invited input from the SEUS on the wording of these elements. OMB felt that the previous roadmap gave conflicting messages. OMB wants something that has more "focus" and one "story" (clearer goals, fewer missions). Dr. Hertz noted that the important thing for the SEUS is to pick the research areas and the missions that will fit into a package that can be funded. There will be important priorities that cannot be included in the first initiative. The science must be prioritized. SEU will not get two new major missions before 2008.

OSS Strategic Planning

Dr. Marc Allen briefly described the 2003 strategic planning process and reviewed the roadmap guidelines. The objective is to have a new OSS Strategic Plan in fall 2003. A Headquarters inter-theme working group devised guidelines on roadmap style and format. The intent of the guidelines is to improve readability and have a degree of uniformity. This will also facilitate the high fidelity "roll-up" to the OSS Strategic Plan. All inputs to the strategic planning process (except the NRC) must flow through the Subcommittee process and roadmaps. The NRC inputs will also be considered by the Subcommittees. Dr. Allen presented the general guidelines and ideas for suggested organization/content. The mission roadmap "time bins" (when the mission goes into development) are 2003-2008; 2009-2014; and 2015-2028 (an extrapolation from the Agency plan). The theme roadmap must also include a technology roadmap, supporting R&A, and Education & Public Outreach (E/PO). E/PO should highlight distinctive opportunities, drawn from the unique aspects of the theme's science and technology. There should be a new, short section on "critical factors"—external or internal factors that have a decisive, enabling, or debilitating effect, e.g., the Deep Space Network (DSN), special laboratory facilities, launch vehicle requirements, international or interagency partnerships, etc. Dr. Allen stated that this has to go into the Strategic Plan; how it goes into the roadmaps is an open question that could be discussed at the Space Science Advisory Committee (SScAC). Astrobiology is a special case. It is a critical science component that cuts across themes. It needs to be represented as a consistent intellectual thread across the theme roadmaps, but not necessarily identical treatment in each roadmap in scope or emphasis. Dr. Allen reviewed the provisional schedule. The roadmap "content" needs to go to NASA Headquarters in September 2002.

Mission Updates

Constellation-X

Dr. Nicholas White reported on the Constellation-X mission. The purpose of the mission is to use x-ray spectroscopy to observe black holes, dark matter throughout the universe, and the production and recycling

of the elements. This mission will enable high resolution spectroscopy of faint x-ray source populations. Constellation-X received strong endorsement from the National Academy of Sciences (NAS) McKee-Taylor Astronomy and Astrophysics survey committee of new facilities for the 2000-2010 timeframe. The mission ranked second in the large space based mission category, behind NGST and ahead of the Terrestrial Planet Finder (TPF). The report said that Constellation-X has been under study for five years and the technology issues are well in hand for a start in the middle of the decade. Dr. White discussed the expected mission performance. Constellation-X will probe close to the event horizon with 100 times better sensitivity than before. Observation of clusters of galaxies is very important to cosmology. Constellation-X observations are essential to understand the structure, evolution, and mass content of the universe. The mission concept is a multiple satellite approach in deep space (L2) orbit. The reference configuration is four satellites, launched two at a time on an Atlas V class vehicle. The mission design is robust and low risk. Dr. White discussed the reference design and showed a summary of the technology roadmap and critical technology development milestones. Substantial technical progress has been achieved, and technology progress is on track to begin flight scale demonstrations. The mission schedule is designed to establish continuity and overlap with Chandra and XMM. First launch is targeted for 2010, with the second launch one year later.

Laser Interferometer Space Antenna (LISA)

Dr. Robin (Tuck) Stebbins provided an overview of the LISA mission. LISA is a partnership between NASA and ESA to observe and measure the rate of massive and super-massive black hole mergers, observe the inspiral and merger of compact stellar objects into massive black holes (MBH), detect gravitational radiation from compact binary star systems in our galaxy, and search for gravitational radiation from the early universe. It will map the gravitational wave sky between 0.1 mHz and 1 Hz to explore astrophysical systems involving compact objects which are rapidly accelerated in non-spherical mass distribution, typically close binary systems. Dr. Stebbins described the mission concept, including orbits, the spacecraft, and the payload. MBH mergers are a primary science objective of LISA. These are extremely important for galaxy evolution. ESA Phase A was completed in 2000. The LISA International Science Team has been initiated. The payload allocation between the US and Europe is under discussion. Dr. Dan Coulter discussed the technology plan. The technology associated with space based detection of low frequency gravitational waves is challenging, but LISA has a substantial technological heritage from a number of relevant ongoing and developing ground and space based investigations. ESA and member nation agencies have made substantial investments in LISA technology. A comprehensive, peer reviewed Technology Plan is being implemented which will provide the necessary capabilities for a successful mission. A joint NASA/ESA flight experiment is planned for 2006. This will validate the most critical, highest risk LISA technologies. Substantial progress is being made in the laboratory in key technology areas. Dr. Coulter reviewed the top-level LISA Technology Development Work Breakdown Structure and development schedule. LISA requires development in three key technology areas: picometer laser interferometry; gravitational sensors; and micro-Newton propulsion. The Disturbance Reduction System (DRS) validation flight consists of two gravitational sensors, eight micro-Newton thrusters, and a laser interferometer. The instrument package will be mounted on a host spacecraft for a June 2006 launch. Dr. Coulter discussed each of the three key technologies. The 1997 cost estimate (total NASA and ESA) for Phases A-E was $465 million. The 2001 total cost estimate is $1.15 billion. The cost to NASA is about $500,000. The major deltas to the 1997 cost estimate are: an increase in science operations from 3 years to 5 years, an increase in reserves (from 14% to 25%), and inflation (development phase from 2003 to 2016 instead of 1999 to 2008). The remainder of the cost deltas are associated with growth in the spacecraft and payload cost estimates, extended Phase A & B, a larger launch vehicle and associated launch costs, and system engineering and mission design.

Energetic X-ray Imaging Survey Telescope (EXIST)

Dr. Jonathan (Josh) Grindlay briefed the Subcommittee on the status of EXIST. EXIST was originally envisioned as a mission on the Space Station. The mission concept is now a free-flyer. EXIST will extend the Roentgen Satellite (ROSAT) and complement GLAST all sky imaging surveys. It will be the first all-sky (every orbit) imaging and variability hard x-ray survey. The key EXIST science will be obscured AGN, blazars, and cosmic diffuse background. Dr. Grindlay reviewed the science and instrument requirements and described the mission concept. Technology development includes coded aperture hard x-ray imaging, CZT detectors, and CZT imagers for 10-600 keV. EXIST was recommended as a medium

mission in the NRC Decadal Survey. Currently, there is partial CZT development support under the balloon program and limited funding for initial GSFC Instrument Synthesis Analysis Lab (ISAL) studies (in 2000 and 2001). Support is needed for technology development and mission formulation: about $1.5 million for CZT-ASIC design; about $1 million for development of low-cost, high yield CZT-ASIC contacts; and about $1 million for development of shield design and detector shield packaging. The total development and operations cost for the EXIST mission is about $350 million. EXIST could launch by 2010 and support GLAST, Constellation-X, NGST, and LSST. Discussions are ongoing with interested international partners for possible mission hardware support.

Micro-Arcsecond X-ray Imaging Mission (MAXIM) Pathfinder

Dr. Webster Cash discussed MAXIM Pathfinder. The MAXIM concept utilizes X-ray interferometry to achieve micro-arcsecond angular resolution. The eventual goal of MAXIM is to take a picture of the event horizon of a black hole. X-ray interferometry has the potential to resolve the event horizon of a supermassive black hole in the nucleus of a nearby galaxy and at the center of our galaxy. The Pathfinder is the mid-step to MAXIM. It will demonstrate the feasibility in space of x-ray interferometry for astronomical applications. It will provide an imaging of x-ray sources with resolution of 100 micro-arcseconds, 5000 times better than Chandra. Dr. Cash described the mission requirements and the interferometer design. The mission consists of an array of grazing incidence mirrors on a mirror spacecraft, creating X-ray interference fringes that are detected on a second detector spacecraft 450 km away. The Integrated Mission Design Center (IMDC) study at GSFC showed that the basic mission design is feasible. There are a number of technology "tall poles." The first is the fabrication of the interferometer, which is in fairly good shape. It has been demonstrated in the laboratory, but the size of the mirrors needs to be increased. Internal metrology is also a challenge. Formation flying, pointing, and position knowledge are challenges. There are a lot of activities going on, but currently there is no funding for the mission. There is some cross-Enterprise participation in the formation flying technology. MAXIM Pathfinder is using an integrated end-to-end modeling environment (also being used by NGST). Within the Strategic Plan, X-ray interferometry is exploration. It utilizes many of NASA's important technologies. X-ray interferometry is now in the SEU Roadmap, with Pathfinder as a mid-term mission. While the Decadal Review was not mission specific with respect to x-ray interferometry, it did recommend technology development funding for this area. The technology plan is based on modest investment now to reduce the pointing stability requirements and provide an optimal target acquisition plan. The initial cost estimate (last year) for MAXIM Pathfinder was just over $1 billion. The target launch is now 2015 and less stability requirements on the interferometer. The mission concept has moved to a CCD array instead of a calorimeter and has reduced the spacecraft separation by a factor of ten.

Government Performance and Results Act (GPRA) Evaluation

Dr. Allen summarized the GPRA requirements and reviewed the Enterprise's contribution to the Agency's 2003 GPRA Performance Report. In 2001, more emphasis was put on the science side, but the whole process has become more complicated. The FY01 Performance Plan has 14 objectives, 7 of which have science components. In the Strategic Plan 2000, there are 24 science focus areas. Dr. Allen asked the SEUS to focus on the progress and scientific results during the fiscal year in the five areas that apply primarily to SEU. Results reported should be noteworthy science that is arguably NASA-supported during the fiscal year. Dr. Allen provided the NASA self-assessment in these areas, but indicated that this narrative would be replaced with the Subcommittee's assessment (if different) and passed to the SScAC. The self-assessment rated all of the Research Focus Areas (RFAs) green, with one exception—testing the general theory of relativity near black holes, which was rated blue. The SEUS agreed with the self-assessment, but advocated some "clean up" to the text. It was agreed that the blue rating should be on RFA 4 because of the Hubble observation of the most distant supernova ever observed. Dr. Margon agreed that some terse additional entries (related to Chandra discoveries) should be added to RFAs 6 and 7 (primarily associated with the ASO theme). The September 21 burst, as an example of High Energy Transient Explorer (HETE) reaching its goals, was added to RFA 3. Minor changes were made to the narratives for the other RFAs.

Discussion:

SEU E/PO folders were made available to the SEUS. Next year, the SEU E/PO activity will be making kits rather than folders. The theme of the kit will be to reinterpret SEU as seeing and exploring the universe.

Material is needed from some of the missions, e.g., the Microwave Anisotropy Probe (MAP) mission and HETE. These missions predated the "E/PO rule." On MAP, the E/PO person is eager to participate but has not been able to get release of material from the mission. The SEUS recommended contacting the Principal Investigator (PI) and working directly with him.

Dr. Hertz reviewed some items that he felt the SEUS might want to comment on: the R&A reorganization, specifically, the two new working groups; and NVO. The Subcommittee also discussed the Senior Review and the value of community input to the Senior Review process. Some of the SEUS members expressed concern over potential redistribution of funds to the NVO. However, the SEUS did not want to make a formal recommendation on this topic at this time. Dr. Margon indicated that he would draft some text for review by the SEUS the following day.

***Tuesday, December 4***

Discussion:
The SEUS reviewed the additions to the GPRA RFAs that were suggested by Dr. Cominsky. In the letter to Dr. Kinney, the SEUS will address the issue of ongoing community input on operations as part of Mission Operations and Data Analysis (MO&DA). Dr. Kinney indicated that she did not feel that there were problems in operations, and that is why it was not highlighted as one of the input areas of the new working group. For example, if there are operations issues with NGST, the NGST Science Working Group should provide guidance on that. Dr. Margon noted that the question was how the community inherits lessons learned on efficient operations. A mechanism for providing lessons learned and efficiencies would be valuable. Dr. Margon suggested that a solution could be a broadening of the charter of the SAWG to make it clear that the acquisition of data (as well as the archive) is intended to be part of the scope. The Senior Review is too far downstream to address transfer of information. This issue is becoming more relevant to the smaller missions.

A suggestion was made to have all of the roadmapping documents on the Web site, and to send an email to the SEUS members when any documents are put on the Web site (or updated). Dr. Margon requested a SEUS fact-finding telecon in February in order for all of the members to get an update on the status of the roadmapping activity.

<u>OSS Update</u>
Dr. Ed Weiler, Associate Administrator for OSS, started his presentation by describing an interesting event in October—Mars Odyssey had a perfect orbital insertion, hitting a target 750 meters in diameter. All climate instruments are working very well. A secondary payload radiation environment instrument failed on the way to Mars and the project will try to work on this when the mission achieves science orbit. HST discovered an atmosphere on an extra-solar planet. Dr. Weiler summarized the OSS FY 2002 Appropriation. The President's Request was $2,786,362. The Bill was signed on November 26, 2001, for $ 2,848,937. The increase was provided to fund a number of earmarks. Every OSS earmark was covered except one—the propulsion research laboratory at MSFC was a partially unfunded earmark and resulted in a $13 million net "damage" to the OSS budget for in-space propulsion technology. Although Congress put in $30 million for a Pluto-Kuiper Belt (PKB) mission, the winning proposal requires upward of $150 million in FY 03. There is no funding in the OSS budget for this. Selection was made for Phase B with major caveats: there is no funding in FY03; show excellent progress towards getting nuclear approval; show that there will be an Atlas V or a Delta IV that will have had several successful launches by 2006; and development of a cost, technical, and schedule plan that is realistic and stands up to independent review. OSS also got some policy direction. Congress agreed that Europa Orbiter could be done at JPL if approved by the Administrator; however, the mission funding is capped at $1 billion. NGST was funded at the requested level. Mars was fully funded. There were no cuts to anything in the SEUS program. NASA received the OMB and budget passback for FY 2003-2007 on November 26, 2001; however, the content is embargoed until the President formally releases the budget request to Congress in late January or early February.

There are seven space science launches scheduled over the next 12 months: the Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) mission, the HST Servicing Mission; High Energy Solar Spectroscopic Imager (HESSI); GALEX, Comet Nucleus Tour (CONTOUR), GP-B, and SIRTF. There is a large concern about the future of small launch vehicles. In response to a question, Dr. Weiler indicated that SOMO and the Consolidated Space Operations Contract (CSOC) funding problems did not result in cancellation of any missions. The cuts will be spread fairly over five years. OSS is now in control of the SOMO budgets and the CSOC for its missions. With respect to strategic planning, Dr. Weiler indicated that whatever mission SEU puts in for a new initiative, it must have a good cost estimate, including 30% reserve. LISA and Constellation-X are the number one and two priorities of the NAS. With respect to community oversight on NASA/NSF astronomy, Dr. Weiler indicated that the proper place for any advisory committee looking at joint NASA/NSF astronomy to report to is SEUS and OS. We do not want another, sixth FACA committee in OSS. OSS is onboard with OMB on this issue. With respect to a national security question, Dr. Weiler noted that we are facing a crisis in this country—population is going up and the number of scientists and engineers is going down. What we do in education has an impact, and we could do more.

Advanced Radio Interferometry between Space and Earth (ARISE)

Dr. Robert Preston briefed the SEUS on iARISE, a proposed international, two-spacecraft, Very Long Baseline Interferometry (VLBI) mission for micro-arcsecond imaging of Supermassive Black Holes (SMBHs) and stellar objects. iARISE improvements over ARISE include: lower cost to NASA, more scientific capability, mature technology, and an earlier possible launch date. iARISE leverages a singular opportunity to accomplish quickly a major, community recognized mission for roughly MIDEX cost. The plan is for two identical spacecraft (one Japanese, one US on a single launch) in complementary orbits. The international partners would share costs. Mission science would be open to all astronomers through peer review. ARISE is presently in the SEU roadmap and the OSS Strategic Plan as a mission for possible implementation after 2007. It was recommended by the NRC Decadal committee. iARISE complements other NASA roadmap missions focused on AGN and supermassive black holes. It would provide unique, high angular resolution images of hard x-ray and gamma ray emitting regions. Dr. Preston compared VLBA, ARISE, and iARISE. All technology needed for iARISE is mature. Some low-cost, low-risk preflight engineering and demonstration is needed. iARISE is an excellent candidate for inclusion in the new SEU roadmap. Dr. Preston distributed a white paper on iARISE to the SEUS.

High-resolution Spectroscopic Imager (HSI)

Dr. Fiona Harrison provided a mission update on HSI, focusing on the science. HSI is a mission that has broad scientific objectives, ranging from studying nuclear lines from supernovae through very high sensitivity spectral and imaging studies, active galactic nuclei and the hard x-ray and soft gamma ray band, galaxy clusters, and neutron stars. The most novel aspect of this mission is the ability to do the nuclear line science with high sensitivity and spectral resolution. HSI will advance angular resolution, sensitivity, and spectral resolution by several orders of magnitude above 10 keV to map supernova remnants at high resolution in $^{44}$Ti, measure $^{56}$Ni decay in Type Ia, and map highly-obscured AGN, galaxy clusters, and pulsars. HSI achieves these breakthroughs on a moderate-scale mission with the first use of focusing optics in the hard x-ray/soft gamma ray band. HSI has been endorsed by the GRAPWG as a high-priority mission. The science is identified in the Quarks to Cosmos phase 1 report. The HSI technology development effort leverages heavily off of SR&T and Constellation-X. HSI can be ready for a new start in early 2008. In response to a question regarding international participation, Dr. Harrison noted that the Italians and the French are extremely interested in this mission as a follow-on to Integral. The Japanese have expressed interest about the detectors. There is potential for the gamma-ray community in Europe to come on-board this mission if it were to go forward. With no international cooperation, the mission would cost about $265 million.

Orbiting Wide-angle Light-collectors (OWL)

Dr. Robert Streitmatter briefed the SEUS on the OWL mission. OWL is a detector system for observing the high energy cosmic ray events coming into the atmosphere. OWL builds on the success of ground-based flys-eyes and HiRes fluorescence observations. The mission concept involves two identical spacecraft flying in formation in a 1000 km, near-equatorial orbit. It is designed to fit within a Delta IV launch vehicle shroud. OWL science is included in the 2000 Space Science Strategic Plan. Dr.

Streitmatter described the major requirements for the optical system. The technical challenge is atmospheric monitoring for variable optical depth, instantaneous aperture, and scattering. Atmospheric monitoring options include: LIDAR onboard OWL, stereo IR detectors on OWL, weather satellites, or a combination of the above. Dr. Streitmatter discussed the modeling procedures, resolution, and aperture. In January 2002, OWL will be worked by the ISAL and the IMDC at GSFC. At the conclusion of this work, there should be a credible cost estimate. OWL has high scientific value. It requires some engineering work, but is technically straightforward. The two greatest needs are work on the atmospheric modeling technique and end-to-end simulation work. In response to a question, Dr. Streitmatter noted that ESA has just begun an EUSO Phase A study. It will fund an accommodation study to go on the Space Station. The experimenters on EUSO have to come up with the resources to do their own instrument phase A, which they are trying to do. Originally, the study was to go through June of next year; it has now been slipped to December of next year. There will not be any decision on EUSO until that point. The EUSO science team will be facing the same issues as OWL with respect to clouds and atmospherics.

Single Aperture Far-IR Telescope (SAFIR)

Dr. David Leisawitz presented a "top-down" view of the mission and showed how SAFIR and the Submillimeter Probe of the Evolution of Cosmic Structure (SPECS) fit into a compelling roadmap. What is important are the science objectives and the roadmap. The "Illuminate the cosmic dark age" roadmap is designed to fulfill the community's top priority (understand how the universe and its constituent galaxies, stars, and planets formed, how they evolved, and what their destiny will be) and answers many important questions. "Big bang to universe today" has popular appeal. NGST will contribute vital information, but will see only half of the light and miss some galaxies and protogalaxies entirely. What is missing are sensitive, high-resolution observations in the far-IR and submillimeter. Dr. Leisawitz discussed why the fundamental goal of astronomy and astrophysics (as stated in the Decadal report) cannot be accomplished without far-IR/submillimeter telescopes. He described the sensitivity and resolution requirements. The Decadal report recommended that SAFIR start at the end of the decade, with investment now in technology to enable IR interferometry in the next decade. Technology for SAFIR and SPECS will be demonstrably achievable when needed. It is already well underway and making good progress.

SuperNova Acceleration Probe (SNAP)

Dr. Saul Perlmutter briefed the SEUS on SNAP, which is a mission that will provide cosmology/dark energy measurements from supernovae. Dr. Perlmutter discussed the implications of an accelerating universe and the problem of the vacuum energy/cosmological constant. An irreducible science goal is measurement of the expansion history of the universe with enough accuracy that a measurement of a change in the properties of the dark energy would be trusted. Dr. Perlmutter discussed why this goal requires SNAP and described what measurements would be required. The primary mission of SNAP is complementary measurements of cosmological parameter, dark matter, and dark energy. SNAP is a observatory consisting of a 3-mirror telescope with separable kinematic mount, an optics bench with instrument bay, a baffled sun shade, and a spacecraft bus supporting telemetry. It has a rigid, simple structure with no moving parts. The satellite would be in high-Earth orbit, providing excellent telemetry to the ground station, no daily eclipses, and passive cooling. The instrumentation consists of a GigaCam imager and spectrograph. Design studies by the IMDC and the ISAL identified no mission or technology "tall poles." The total runout cost (including launch and contingency) is about $350 million. SNAP is still in study phase, and the project is being developed as a multi-agency partnership. DOE and NSF's SAGENAP panel conducted a peer review of the science in March 2000. The review panel gave strong endorsement of the science and recommended SNAP for study funding. In January 2001, a DOE/Science & R&D Review released several findings: that SNAP is a science-driven project with compelling scientific goals; that it will have a unique ability to measure the variation in the equation of the state of the universe; and that Type Ia supernova measurements will uniquely address issues at the very heart of the particle physics field. The NRC Decadal Survey identified dark energy as one of the key topics that needs to be addressed. (SNAP was formulated after the Decadal Survey's data collection phase.) The HEPAP 20-year planning report gave a strong endorsement for continued development of SNAP. The NRC Committee on Physics of the Universe reviewed SNAP in July 2001 as part of its Phase II study and will be reporting in the spring. SNAP will be a resource for the entire science community. It will be the only wide-field deep survey in space with HST resolution.

Discussion of Issues

Dr. Margon noted that SEUS has gotten feedback that the last roadmap had too many "things" in it. Dr. Weiler appears to be eager to sell LISA and Constellation-X. The questions are: Where is the middle ground? What new roadmap can the SEUS imagine that meets all of the constraints? Dr. Kinney indicated that what is important is that the difficult decisions be made and that the missions be prioritized. At the time of the last roadmap, the Decadal Survey was going on in parallel, and there was a reluctance to eliminate missions so that they could be reviewed in the Decadal Survey. Now that SEU has the Decadal Survey, the SEUS can pull back some of the missions that it wasn't sure about three years ago. Dr. Margon agreed that the SEUS should consider the Decadal Survey very carefully in the roadmapping process. Last time, the roadmap attempted to give something to every wavelength regime. This time, some meritorious wavelength regimes could be omitted from the roadmap. The political landscape is such that the mid-term missions must be something that LISA and Constellation-X point very clearly toward. It is clear that there must be a less ambitious "plate" in this timeframe. Dr. Kinney added that if OSS doesn't get an augmentation, SEU could be in serious trouble with LISA.

Joint Discussions with the Origins Subcommittee (OS)

Dr. Margon reviewed several issues identified by SEUS. It received a detailed presentation on SNAP. The project is much better defined. There do not appear to be any technical show-stoppers. The total estimate is about $350 million. The current anticipation is about 50% or more contribution from other partners (DOE and others). SEUS made no resolution on what to do next. SEUS has received signals that the last roadmap was not focused beyond the near term. The Enterprise Strategic Plan included all six mid-term missions. The next roadmap needs be more focused in the mid-term. The last SEU roadmap discussed both a far infrared (FIR) interferometer and a large single aperture FIR telescope in the mid-term. It is unclear whether the scientific case would fit crisply into the SEU theme. Dr. Dressler noted that in the last OS roadmap, there was a discussion of the Filled Aperture Infrared (FAIR) telescope mission and there was interest in a next-generation NGST, further into the IR. However, it was not one of the missions at the level of TPF. Dr. Margon invited the OS to hear more about the FIR mission and asked the OS to consider whether this type of FIR mission, if it is of interest to the ASO theme, would fit better into the OS roadmap.

Unlike the OS process, there is a Roadmapping Team that is writing the SEU roadmap. Several members of the SEUS are on this Team. Dr. Dressler indicated that he would ensure that the appropriate OS people coordinate with the SEU Team. The SEU Roadmapping Team plans to meet on February 26-27, 2002.

The SEUS received a briefing on the two new A&P Working Groups, and suggested that the SAWG charter include the "up front" stages of data (i.e., data handling) for small missions.

Dr. Margon noted that this would be his last meeting as SEUS Chair and member of SScAC. In addition, there will be relatively large turnover in membership of the Subcommittee.

Dr. Dressler noted that the OS is also headed toward a "crisper" roadmap and has work to do on the document. The next HST servicing mission in January will be very challenging. The OS supports the Servicing plan for HST, with the last servicing mission in 2004. This will provide the best chance to maintain capability until 2010. However, the probability of HST surviving to 2010 is not terribly encouraging. There has been discussion in the community about a possible additional servicing mission and how that would impact NGST. The group at GSFC has been looking at the possibility of a servicing mission in 2007, with accommodation (propulsion module) for safe deorbit, but the feasibility and cost of such a mission is not clear. The OS encourages an open mind to possible opportunities to maintain HST capability, but not at the expense of NGST. The ASO community has clearly indicated its priority for NGST.

Dr. Squyres noted that it is important that as the OS and SEUS go forward with the roadmapping activity, they are sensitive to the perception in the community that there are certain disciplines that "fall through the crack" between the two themes (e.g., UV and optical). There is also a concern in the community about losing facility access.

The Subcommittees discussed the questions: Should there be a $300 million Explorer Program? How could the larger missions be addressed?

At the request of the SEUS, Dr. Riegler briefed the Subcommittees on COMRAA. It recommended a joint NASA/NSF committee with joint chairmanship and that this coordinating committee on astronomy and astrophysics should be advised by a separate advisory group. NASA and NSF jointly responded—a more effective process is for NASA and NSF to continue their own coordination and that there should be a bilateral advisory group that advises the two efforts. For NASA the outside advisory group should be subordinate to the existing advisory structure. The key elements were accepted by OMB. On the NSF side, they will set up a formal advisory structure for astronomy and astrophysics. On the NASA side, we will ask existing members of SEUS and OS (and perhaps SScAC) to serve on the committee. The proposed name of the committee is: National Astronomy and Astrophysics Committee (NAAC). The committee will advise NASA and NSF on specific questions asked by the two agencies. Chairmanship will rotate between the NASA side and the NSF side. One of the first questions will be: Are there areas of duplication or gap?

# AGENDA
## Structure and Evolution of the Universe Subcommittee (SEUS)
## December 3-4, 2001
## Hilton Cocoa Beach Oceanfront
## Sea Oats Room

Monday, December 3

| | | |
|---|---|---|
| 8:30- 8:45 | Introduction and Announcements | B. Margon |
| 8:45- 9:25 | SEU Theme Update | P. Hertz |
| 9:25- 9:30 | Break (OS joins SEUS) | |
| 9:30-10:30** | Astronomy & Phyics Division Update | A. Kinney |
| 10:30-11:00** | R&A Plans | H. Hasan |
| 11:00-11:15 | Break | |
| 11:15-12:00 | Roadmap Team Report | S. Phinney |
| | | |
| 12:00- 1:00 | Working Lunch | |
| 12:30- 1:00 | OSS Strategic Planning | M. Allen |
| | | |
| 1:00- 2:30 | Mission Updates 1 | |
| | Con-X [30 min + 15 min discussion] | N. White |
| | LISA [30 min + 15 min discussion] | T. Prince |
| 2:30- 2:45 | Break | |
| 2:45- 4:00 | Mission Updates 2 | |
| | EXIST [20 min + 10 min discussion] | J. Grindlay |
| | MAXIM Pathfinder [20 min + 10 min] | W. Cash |
| 4:00- 5:00 | GPRA Evaluation | M. Allen |
| 5:00- 6:00 | Discussion | All |

Tuesday, December 4

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|---|---|---|
| 8:30- 9:00 | Discussion | All |
| 9:00-10:00 | OSS Update | E. Weiler |
| 10:00-12:00 | Mission Updates 3 | |
| | ARISE [20 min + 10 min discussion] | R. Preston |
| | HSI [20 min + 10 min discussion] | F. Harrison |
| | OWL [20 min + 10 min discussion] | R. Streitmatter |
| | SAFIR [20 min + 10 min discussion] | H. Yorke |
| | | |
| 12:00- 1:00 | Working Lunch | |
| | | |
| 1:00- 1:45 | Mission Updates 4 | |
| | SNAP [30 min + 15 min discussion] | S. Perlmutter |
| 1:45- 2:45 | Discussion of Issues | All |
| 2:45- 3:00 | Break; OS joins SEUS | |
| 3:00- 5:00 ** | Discussion with OS, Brief to Kinney | B. Margon |
| 5:00 | Adjourn | |

** Joint session with Origins Subcommittee (OS) in the Sea Oats Meeting Room.

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
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STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
December 3-4, 2001
Cocoa Beach, FL

MEETING ATTENDEES

*Subcommittee Members:*

| | |
|---|---|
| Margon, Bruce H. *(Chair)* | Space Telescope Science Institute |
| Cominsky, Lynn R. | Sonoma State University |
| Flanagan, Kathryn | Massachusetts Institute of Technology |
| Hertz, Paul *(Executive Secretary)* | NASA Headquarters |
| Kamionkowski, Marc | California Institute of Technology |
| Lester, Daniel | University of Texas |
| McCammon, Daniel | University of Wisconsin |
| Peterson, Bradley | Ohio State University |
| Phinney, E. Sterl | California Institute of Technology |
| White, Nicholas | NASA/GSFC |
| Yorke, Harold | NASA/JPL |

*NASA Attendees:*

| | |
|---|---|
| Allen, Marc | NASA Headquarters |
| Coulter, Dan | NASA/JPL |
| Cramer, Bryant | NASA/GSFC |
| Hartman, Colleen | NASA Headquarters |
| Howard, Rick | NASA Headquarters |
| Kinney, Anne | NASA Headquarters |
| Kniffen, Donald | NASA Headquarters |
| Leistwith, Dave | NASA/GSFC |
| Niebor, Susan | NASA Headquarters |
| Norris, Marian | NASA Headquarters |
| Preston, Robert | NASA/JPL |
| Riegler, Guenter | NASA Headquarters |
| Sadof, Donna Walls | NASA/GSFC |
| Sakimoto, Phil | NASA Headquarters |
| Schwartz, Chris | NASA Headquarters |
| Sorrels, Carrie | NASA Headquarters |
| Stebbin, Robin | NASA/GSFC |
| Streitmatter, Robert | NASA/GSFC |
| Trotta, Ann Marie | NASA Headquarters |
| Unwin, Stephen | NASA/JPL |
| Varsi, G. | NASA/JPL |

*Other Attendees:*

| | |
|---|---|
| Cash, Webster | University of Colorado |
| Church, Sarah | Stanford University |
| DiBiasi, Lamont | L. DiBiasi Associates |
| Fomalont, Ed | NRAO |
| Greenhill, Lincoln | CfA |
| Grindlay Josh | Harvard University |
| Harrison, Fiona | California Institute of Technology |
| Hawkins, Isabel | University of California, Berkeley |

| | |
|---|---|
| Hinners, Noel | LMC |
| Hogan, Craig | University of Washington |
| Kolb, Edward (Rocky) | FNAL |
| Levi, Michael | LBNL |
| Malay, Jon | Ball |
| Mardi, Robert | University of Wisconsin |
| Prince, Tom | CalTech/JPL |
| Purdy, William, Jr. | Ball Aerospace |
| Reid, Mark | CfA |
| Richstone, Douglas | University of Michigan |
| Sellgren, Kris | OSU |
| Shull, Mike | University of Colorado |
| Squyres, Steve | Cornell University |
| Turner, Kathy | Department of Energy |

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
December 3-4, 2001
Cocoa Beach, FL

FINDINGS AND RECOMMENDATIONS

[letter from Dr. Margon to Dr. Kinney to be inserted here]

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
December 3-4, 2001
Cocoa Beach, FL

LIST OF PRESENTATION MATERIAL[1]

1) Astronomy and Physics Operating Missions [Hertz]
2) Astronomy and Physics Division Advisory Structure [Kinney]
3) Astronomy and Physics Research Programs [Hasan]
4) Strategic Planning 2003 Status [Allen]
5) Constellation X-ray Mission [White]
6) Laser Interferometer Space Antenna [Prince]
7) EXIST: Surveying the Obscured and Extreme Universe [Grindlay]
8) GPRA Performance Report 2003 [Allen]
9) Presentation to the Space Science Advisory Committee and Subcommittees [Weiler]
10) iARise [Preston]
11) High-resolution Spectroscopic Imaging Mission [Harrison]
12) The Orbiting Wide-angle Light-collectors [Streimatter]
13) SAFIR: Illuminating the Cosmic Dark Age [Yorke]
14) SuperNova Acceleration Probe [Perlmutter]

Other material distributed at the meeting:

1) Astrobiology and the Roadmapping Process
2) Theme Roadmap Document Guidance
3) IARISE: Zooming in on Black Holes

[1] Presentation and other materials distributed at the meeting are on file at NASA Headquarters, Code S, Washington, DC 20546.